C/041/0002
cc: A Abate

Canyon Fuel Company, LLC.
Sufco Mine
A Subsidiary of Arch Western Bituminous Group, LLC.

#3580
Q

Ken May, General Manager
597 South SR 24
Salina, UT 84654
(435) 286-4400 - Office
(435) 286-4499- Fax

June 15, 2010

COPY

Mr. Daron Haddock
Permit Supervisor
Utah Coal Regulatory Program
Utah Division of Oil, Gas and Mining
1594 West North Temple, Suite 1210
P. O. Box 145801
Salt Lake City, Utah 84114-5801

Re: Proposed 2010 Mitigation Activities for the North Water Spring Area, Canyon Fuel Company, LLC, SUFCO Mine C/041/0002

Dear Mr. Haddock:

Copies of the attached plan and Division forms C-1 and C-2 are being submitted for the Proposed 2010 Mitigation Activities for the North Water Spring Area for the Sufco Mine.

If you have any questions or need additional information, please contact Leland Roberts at (435) 286-4483.

Sincerely,
CANYON FUEL COMPANY, LLC
SUFCO Mine

for Ken May

Kenneth E. May
General Manager

Encl.

KEM/FLR:kb

cc: DOGM Correspondence File

sufpub\govt2010\dogmmrp\MRP North Water Springs ltr.doc

File in:
☐ Confidential
☐ Shelf
☒ Expandable
Date Folder 06222010 / Incoming

RECEIVED
JUN 2 2 2010
DIV. OF OIL, GAS & MINING

APPLICATION FOR COAL PERMIT PROCESSING

COPY

Permit Change ☒ New Permit ☐ Renewal ☐ Exploration ☐ Bond Release ☐ Transfer ☐

Permittee: CANYON FUEL COMPANY, LLC
Mine: SUFCO MINE **Permit Number:** C/041/002
Title: 2010 Mitigation Activities for the North Water Spring Area
Description, Include reason for application and timing required to implement:

Instructions: If you answer yes to any of the first eight (gray) questions, this application may require Public Notice publication.

☐ Yes ☒ No 1. Change in the size of the Permit Area? Acres: _____ Disturbed Area: _____ ☐ increase ☐ decrease.
☐ Yes ☒ No 2. Is the application submitted as a result of a Division Order? DO# _____
☐ Yes ☒ No 3. Does the application include operations outside a previously identified Cumulative Hydrologic Impact Area?
☐ Yes ☒ No 4. Does the application include operations in hydrologic basins other than as currently approved?
☐ Yes ☒ No 5. Does the application result from cancellation, reduction or increase of insurance or reclamation bond?
☐ Yes ☒ No 6. Does the application require or include public notice publication?
☐ Yes ☒ No 7. Does the application require or include ownership, control, right-of-entry, or compliance information?
☐ Yes ☒ No 8. Is proposed activity within 100 feet of a public road or cemetery or 300 feet of an occupied dwelling?
☐ Yes ☒ No 9. Is the application submitted as a result of a Violation? NOV # _____
☐ Yes ☒ No 10. Is the application submitted as a result of other laws or regulations or policies?
Explain: _____
☐ Yes ☒ No 11. Does the application affect the surface landowner or change the post mining land use?
☐ Yes ☒ No 12. Does the application require or include underground design or mine sequence and timing? (Modification of R2P2)
☐ Yes ☒ No 13. Does the application require or include collection and reporting of any baseline information?
☐ Yes ☒ No 14. Could the application have any effect on wildlife or vegetation outside the current disturbed area?
☐ Yes ☒ No 15. Does the application require or include soil removal, storage or placement?
☒ Yes ☐ No 16. Does the application require or include vegetation monitoring, removal or revegetation activities?
☐ Yes ☒ No 17. Does the application require or include construction, modification, or removal of surface facilities?
☐ Yes ☒ No 18. Does the application require or include water monitoring, sediment or drainage control measures?
☐ Yes ☒ No 19. Does the application require or include certified designs, maps or calculation?
☐ Yes ☒ No 20. Does the application require or include subsidence control or monitoring?
☐ Yes ☒ No 21. Have reclamation costs for bonding been provided?
☐ Yes ☒ No 22. Does the application involve a perennial stream, a stream buffer zone or discharges to a stream?
☐ Yes ☒ No 23. Does the application affect permits issued by other agencies or permits issued to other entities?

Please attach four (4) review copies of the application. If the mine is on or adjacent to Forest Service land please submit five (5) copies, thank you. (These numbers include a copy for the Price Field Office)

I hereby certify that I am a responsible official of the applicant and that the information contained in this application is true and correct to the best of my information and belief in all respects with the laws of Utah in reference to commitments, undertakings, and obligations, herein.

KENNETH E. MAY, MINE MANAGER
Print Name

[signature], Mgr. Tech Services 6-15-10
Sign Name, Position, Date

Subscribed and sworn to before me this 15 day of June, 2010

Krystal Rickenbach
Notary Public

My commission Expires: __________, 20___ }
Attest: State of __________ } } ss:
County of __________

NOTARY PUBLIC
KRYSTAL RICKENBACH
580808
My Commission Expires
November 10, 2013
STATE OF UTAH

For Office Use Only:	Assigned Tracking Number:	Received by Oil, Gas & Mining
		RECEIVED JUN 22 2010 DIV. OF OIL, GAS & MINING

APPLICATION FOR COAL PERMIT PROCESSING
Detailed Schedule Of Changes to the Mining And Reclamation Plan

COPY

Permittee: CANYON FUEL COMPANY, LLC
Mine: SUFCO MINE **Permit Number:** C/041/002
Title: 2010 Mitigation Activities for the North Water Spring Area

Provide a detailed listing of all changes to the Mining and Reclamation Plan, which is required as a result of this proposed permit application. Individually list all maps and drawings that are added, replaced, or removed from the plan. Include changes to the table of contents, section of the plan, or other information as needed to specifically locate, identify and revise the existing Mining and Reclamation Plan. Include page, section and drawing number as part of the description.

			DESCRIPTION OF MAP, TEXT, OR MATERIAL TO BE CHANGED
☒ Add	☐ Replace	☐ Remove	Add proposed 2010 mitigation activities for the north water spring area to Appendix 7-22 in Volume 8 of MRP.
☐ Add	☐ Replace	☐ Remove	
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Any other specific or special instruction required for insertion of this proposal into the Mining and Reclamation Plan.	**Received by Oil, Gas & Mining**
	RECEIVED JUN 22 2010 DIV. OF OIL, GAS & MINING

Form DOGM - C2 (Revised March 12, 2002)

Canyon Fuel Company, LLC.
Sufco Mine
A Subsidiary of Arch Western Bituminous Group, LLC.

F. Leland Roberts
Environmental Engineer
597 South SR 24
Salina, UT 84654
(435) 286-4483 - Office
(435) 286-4499 - Fax

June 11, 2010

Coal Regulatory Program
Attn.: Daron Haddock
Division of Oil, Gas and Mining
1594 West North Temple, Suite 1210
Box 145801
Salt Lake City, Utah 84114-5801

RE: Proposed 2010 Mitigation Activities for the North Water Spring Area, Canyon Fuel Company, LLC, SUFCO Mine, C/041/0002

Dear Mr. Haddock:

Sufco respectfully submits to the Division of Oil, Gas and Mining (Division) this letter outlining the investigation and mitigation activities the mine plans for the North Water Spring area for 2010. In 2009 the mine drilled and completed 5 monitoring wells into the contact between the Castlegate Sandstone and Blackhawk Formation. Slug tests of the wells were conducted by Erik Petersen of Petersen Hydrologic, LLC. and mine staff. A brief summary of those findings is included within this letter and the full report can be found in Appendix A. Based on information obtained over the last year the mine has determined that drilling and completing shallow production wells near Pines 105, 310, and 311 and the Joe's Mill Pond would yield minimal groundwater. Therefore the mine is proposing pumping water from a spring near the confluence of the Main Fork of Box Canyon and the East Fork of Box Canyon to the affected springs in the Pines Area.

Summary of 2009 Drilling Activities and Slug Tests

In the summer of 2009, five monitoring wells where drilled and completed with 1" PVC casing as outlined in the current Sufco M&RP. Monitoring of water depths in the wells was conducted in 2009 and 2010 with slug tests being conducted in 4 of the wells in 2009 by Erik Petersen and mine staff. Slug tests indicated that, at this time, it was unlikely that any well completed at the interface of the Castlegate Sandstone and Blackhawk Formation would produce a sustainable water source for the replacement water needed. Erik Petersen's complete report has been included in Appendix A.

Future Proposed Activities

In 2010 Sufco is proposing pumping water from spring M-SP89 to Pines 105, 310, and 311 (the Pines), and the Joe's Mill Seep. Spring M-SP89 is located on the north facing slope of the canyon where the Main Fork of the Box Canyon and the East Fork of Box Canyon meet. The spring is located approximately 400 feet below the canyon rim, about midway down the slope. The spring has been monitored periodically by Sufco since 2001 and the average flow is around 20 gallons per minute (gpm), Table 1. Water from this spring runs down slope from the source for a short distance before soaking back into the colluvium. Sufco is proposing to divert approximately 10 gpm from M-SP89 to replace displaced flows in the North Water Spring and at Joe's Mill Pond areas.

M-SP89 Flow Data		
Date (m/yr)	Flow (gpm)	Sampler
Oct-01	15-20	C Hansen
Apr-02	28	C Hansen
Aug-02	20	C Hansen
Sep-06	30.4	E. Petersen
May-10	20	E. Petersen
May-10	20	E. Petersen

Table 1 M-SP89 Flows

Sufco would place a spring collection box at the source of the spring to collect the majority of the flow. This water would be diverted into a second enclosed box that would house solar powered electric pump, with an overflow structure to direct excess water back into the spring area. Water would be pumped from this second box into a 2" HDPE water line to the rim of the canyon and then south up to a diversion box that would be buried on the hill separating the two canyons (Figure 1). Water would then gravity-flow in a 2" line east from the diversion box off the rim and up the North Water Spring Canyon (East Fork of the East Fork of Box Canyon) to spring Pines 105 (North Water Spring), Pines 311 and 312(?). A tee would be placed in the 2" line at the confluence of the East Fork of Box Canyon with the North Water Spring Canyon to divert approximately 1 gpm to Joe's Mill Pond. A valve would be placed after the tee in order to control the flow going to the pond seep area. Water from the pipe would daylight to the ground surface near the location of the original Joe's Mill Pond seep.

Valves would be used to control flow so that Pines 105 would receive approximately 6 -7 gpm and Pines 310 and 311 would each receive approximately 1 gpm. Water would be run on the ground at the same approximate locations that springs Pines 310 and 311 discharged and into the current spring box at Pines 105. See Figure 1 for all locations.

Due to its remote location in dense conifer growth there does not appear to be a riparian community supported by spring M-SP89. Abundant evidence of livestock use of this spring as a watering source has been observed in recent years. To prevent disturbance to the spring collection box and pump box, a small area around the spring would be fenced. Overflow from the pump box would be routed into the existing shallow channel to allow continued livestock and wildlife use of the spring as a watering source. Since Sufco is only proposing using half of the flow from the spring no negative impacts to vegetation or watering uses of the spring are expected.

The feasibility of directional drilling a borehole from the canyon rim to the spring site to run power cables from solar panels to the pump is being investigated. It may also be feasible to run the 2-inch water line in a directionally drilled borehole from the spring to the canyon rim. Once the water line reaches the top of the canyon Sufco is proposing the use of a small trencher to bury the 2" HDPE pipe. This trencher will enable the water line to be protected from vandalism and freezing. Impacts from trenching is viewed to be minimal as only one pass would be made to trench and lay the pipe with back filling happening immediately. The proposed route is shown on Figure 1. Trenching in the East Fork of Box and the East Fork of the East Fork of Box would be done on one side of the canyon to minimize any disturbance to the HDPE water lines from high water events. The disturbance would be reseeded with an appropriate seed mix immediately following burial of the HDPE water lines and the diversion box.

Lockable boxes enclosing the water system valves and distribution ends will be constructed of durable materials and placed in locations that are easily accessible and protected from high stream flows. The solar panels will be located in the area as indicated on Figure 1 and will be surrounded by a pole fence. End-of-pipe locations where water is discharged to spring and seep areas will also be protected with both durable discharge structures and pole fencing. The discharge structures will be designed and built to withstand environmental conditions and abuse from livestock and wildlife. The mine is still in the process of determining the best pumping equipment as well as solar panel sizes for this process. The pump size and configuration will determine the dimension of the spring collection box. As soon as that information is developed, it will be forwarded to the Division. It is anticipated the construction of the spring collection system will be completed by hand with transportation of some materials taking place with the aid of a helicopter. Existing roads will be used to access the proposed solar panel location. No new roads would be proposed as part of this project. Surface reclamation of the water line trench will be conducted in such a manner as to discourage the use of the route by motorized vehicles.

If you have any questions regarding this proposal, please contact me at (435) 286-4483

Sincerely,
CANYON FUEL COMPANY, LLC
SUFCO Mine

F. Leland Roberts

F. Leland Roberts,
Environmental Engineer

ec: John Byars, Sufco Mine
Chris Hansen, Arch Western Bituminous Group
Mike Davis, Sufco Mine
Dale Harbor, Manti LaSal National Forest
Steve Rigby, USBLM/Manti LaSal National Forest
Jeff McKenzie, USBLM

Attach.

FIGURE 1

Proposed Water Line

Canyon Fuel Company, LLC
SUFCO Mine
397 South 800 West - Salina, UT 84654
(435) 286-4880 Phone
(435) 286-4499 Fax

Figure 1

2010 Northwater Mitigation Proposed Water Line

SCALE: 1" = 1000' | DATE:6/11/2010 | DRAWN BY:K.B.B. | ENGINEER:F.L.R. | CHECKED BY:F.L.R.

FILE NAME: H:\DRAWINGS\MAPSURF\EAST FORK BOX\StockWater\dwg\2010 Mitigation.dwg

REVISIONS

NO.	DATE	REQ. BY	DWG. BY	REMARKS
1	05/27/10	F.L.R.	K.B.B.	LOCATED SPRING 89
2	06/11/10	F.L.R.	F.L.R.	ADDED WATER LINES

SHEET NO.

1

Appendix A

Castlegate Sandstone Bedrock Wells Report

Results of Well Drilling and Slug Testing of Castlegate Sandstone Bedrock Monitoring Wells in the North Water Canyon and Joes Mill Pond Areas, Canyon Fuel Company, LLC, SUFCO Mine C/041/002

4 April 2010

Canyon Fuel Company, LLC
Sufco Mine
Salina, Utah

PETERSEN HYDROLOGIC, LLC
CONSULTANTS IN HYDROGEOLOGY

Results of Well Drilling and Slug Testing of Castlegate Sandstone Bedrock Monitoring Wells in the North Water Canyon and Joes Mill Pond Areas, Canyon Fuel Company, LLC, SUFCO Mine C/041/002

4 April 2010

Canyon Fuel Company, LLC
SUFCO Mine
Salina, Utah

Prepared by:

LICENSED PROFESSIONAL GEOLOGIST
ERIK CARL PETERSEN
No. 5373615-2250
STATE OF UTAH

Erik C. Petersen, P.G.
Senior Hydrogeologist
Utah P.G. No. 5373615-2250

PETERSEN HYDROLOGIC, LLC
CONSULTANTS IN HYDROGEOLOGY

2695 N. 600 E.
LEHI, UTAH 84043
(801) 766-4006

Table of Contents

List of Figures

List of Tables

List of Appendices

Results of Well Drilling and Slug Testing of Castlegate Sandstone Bedrock Monitoring Wells In the North Water Canyon and Joes Mill Pond Areas, Canyon Fuel Company, LLC, SUFCO Mine C/041/002

1.0 Introduction

During July and August of 2009, Canyon Fuel Company, LLC commissioned the drilling of five drill holes in the Castlegate Sandstone bedrock in the North Water Canyon and Joes Mill Pond areas overlying their Sufco Mine (Figure 1). The purpose of this drilling program was to further characterize groundwater systems in the Castlegate Sandstone and to evaluate the potential for production of groundwater from the Castlegate Sandstone for use in the mitigation of diminished groundwater flows that have occurred in the area subsequent to undermining and subsidence.

Previous investigations regarding groundwater and surface-water systems and the effects of mining subsidence on the hydrologic balance in the North Water Canyon and Joes Mill Pond areas have been performed. In 2006, Canyon Fuel commissioned Petersen Hydrologic, LLC to perform a hydrogeologic investigation of alluvial and shallow bedrock groundwater systems and subsidence-related impacts in the North Water Canyon and Joes Mill Pond areas. In January 2007 a report of this investigation, including proposed mitigation activities, was prepared and submitted to the Utah Division of Oil, Gas and Mining. This report is entitled *Investigation of Subsidence-Related Impacts to Groundwater Systems in the North Water and Joes Mill Pond areas and Proposed Groundwater Mitigation Activities, Sufco Mine,* dated 29 January 2007 (Petersen Hydrologic, 2007a).

In November, 2007, an additional hydrologic investigation was performed in the North Water Canyon and Joes Mill Pond areas. A report summarizing the findings of that investigation is entitled: *Report of 2007 Hydrogeologic Field investigations; Supplemental information for the report: Investigation of Subsidence- Related Impacts to Groundwater Systems in the North Water and Joes Mill Pond areas and Proposed Groundwater Mitigation Activities, Sufco Mine,* dated 7 November, 2007 (Petersen Hydrologic, 2007b). This report was also submitted to the Utah Division of Oil, Gas and Mining.

The reader is referred to these documents for additional information on the geologic and hydrogeologic conditions and on the effects of mining-related activities in the North Water Canyon and Joes Mill Pond areas.

The purpose of this investigation is to present the results of the 2009 drilling program and to provide an analysis of the potential to produce groundwater from the bedrock formations underlying the North Water Canyon and Joes Mill Pond areas.

Including this introduction, this report contains the following sections:

- Methods of Study
- Presentation of Data
- Hydrogeologic Conditions
- Conclusions and Recommendations
- References Cited
- Appendices

2.0 Methods of Study

- The well drilling operations were performed by Lang Exploratory Drilling of Salt Lake City, Utah using continuous coring techniques. The five drill holes were drilled using HQ sized drilling equipment and a polymer-based drilling fluid. Drilling supervision and geologic logging of the drilling cores were performed by Mr. Craig Clement of Clement Drilling and Geophysical, Inc. of Cedar Hills, Utah. The drill cores were placed in core boxes and stored at the Salina, Utah offices of Canyon Fuel Company, LLC for future analysis.

- One-inch diameter PVC monitoring wells were installed in each of the five drill holes to allow the monitoring of water levels and for aquifer testing. The construction of the monitoring wells was supervised by Mr. Craig Clement of Clement Drilling and Geophysical, Inc., who is a Utah State licensed water well driller. Subsequent to the construction of the wells, the wells were developed using surging and bailing techniques.

- Water levels in the five monitoring wells were monitored periodically after their construction using an EnviroTech model 500 water-level meter.

- Slug testing was performed on wells NW1-09, NW2-09, NW4-09, and JMP-09 on 6 November 2009. Slug testing was performed by rapidly introducing water into the well casing. Declining head levels during the slug testing were then monitored using an In-Situ Inc. brand LevelTROLL 500 model pressure transducer/data logger. A preliminary injection test was performed on well NW3-09. However, based on the results of the initial injection test, slug testing was not performed on well NW3-09.

- Slug test results were calculated using methods described by Hvorslev (1951).

3.0 Presentation of Data

The locations of the five Castlegate Sandstone bedrock monitoring wells are shown on Figure 1. A north-south cross-section through the North Water Canyon area is provided as Figure 2. Monitoring well completion data are depicted graphically in Figure 3. Completion information for the five monitoring wells is provided in tabular form in Table 1. Water level measurements for the wells are presented in Table 2. Slug test results are presented in Table 3. Geologic logs of the drill core from the five drill holes are presented in Appendix A.

Calculations and assumptions used in computing the slug test results are provided in Appendix B.

4.0 Hydrogeologic Observations

As indicated on Table 1, the five drill holes range in depth from 168 to 228 feet below the ground surface. Each of these holes penetrates some distance into the Blackhawk Formation, which directly underlies the Castlegate Sandstone in the North Water Canyon and Joes Mill Pond areas. It is noteworthy that the screened intervals for all of the five monitoring wells are all or in part located in the Blackhawk Formation as summarized below.

	Feet of well screen in the Castlegate Sandstone	Feet of well screen in the Blackhawk Formation	Percentage of screen in Castlegate Sandstone	Saturated thickness of Castlegate Sandstone*
NW1-09	0	40	0	1.2
NW2-09	3.8	16.2	19	18.3
NW3-09	0.5	19.3	3	4.5
NW4-09	5	15	25	2.3
JMP-09	11	29	37	7

*Note: Saturated thickness assumes unconfined conditions; water levels measured in November 2009 and February 2010. Figures are approximate.

Slug testing activities performed and the results of the slug tests on the four bedrock monitoring wells tested are summarized below.

It should be noted that while the conditions in the monitoring wells varied, the conditions strictly required to perform valid slug testing were not present in any of the wells. The conditions in the four tested monitoring wells are summarized below.

	Water level above well screen (required for valid test)	Water level above sand pack (required for low-K valid test)	Screened in Castlegate or Blackhawk
NW1-09	Yes	No	Blackhawk
NW2-09	Yes	No	Composite (almost all Blackhawk)
NW4-09	No	No	Composite (mostly Blackhawk)
JMP-09	No	No	Composite (mostly Blackhawk)

It is apparent from the information above that none of the wells met the criteria required for a valid slug test. Conditions at NW1-09 and NW2-09 were invalid because a portion of the sand pack was unsaturated, while the testing of wells NW4-09 and JMP-09 were invalid because an appreciable portion of the sand pack was above the water level and the well screens were partially above the water level. However, slug testing results were calculated for each of these four monitoring wells for general evaluative purposes. It should be noted that under the best of circumstances, slug tests are generally considered useful for making order-of-magnitude determinations of hydraulic conductivity. Accordingly, this information should be considered in light of the less-than-optimal conditions that existed in the wells. The slug test results should be considered approximations only. Additionally, because of the nature of the completions of the wells (i.e., the well screened intervals are all or mostly in the Blackhawk Formation), it is should be noted that the hydraulic conductivity values reported above are <u>not</u> indicative of conditions in the Castlegate Sandstone.

	Hydraulic Conductivity* (well slotted screen length assumption)	Hydraulic Conductivity* (screen length equals sand pack length assumption)
NW1-09	1.56×10^{-5} cm/sec	8.13×10^{-6} cm/sec
NW2-09	1.41×10^{-4} cm/sec	5.94×10^{-5} cm/sec
NW3-09	Not tested	Not tested
NW4-09	2.11×10^{-4} cm/sec	1.04×10^{-4} cm/sec
JMP-09	2.04×10^{-4} cm/sec	1.55×10^{-4} cm/sec

*Note: As described in previous sections, one or more conditions required for a valid slug test were not present in the wells.

The values of hydraulic conductivity presented above were calculated using the Hvorslev (1951) method. The results listed in the first column were calculated using the assumption that the length of the well screen is equal to the physical length of slotted well screen (commonly assumed when slug testing in high-permeability strata. The results listed in the second column were calculated using the assumption that the screen length equals the total length of the gravel pack. This assumption is commonly employed when testing low-permeability strata.

The order of magnitude estimates for hydraulic conductivity presented above for wells NW1-09 and NW2-09 are consistent with published values for sandstone bedrock (Freeze and Cherry, 1979). The hydraulic conductivity values for wells NW4-09 and JMP-09 are somewhat greater (near the upper end of the range for sandstone). It seems probable that the hydraulic conductivity values presented for these two wells are less reliable than are the other two wells tested. As depicted in Figure 3, the completion characteristics for these two wells are not favorable for a valid slug test. Additionally, as shown in Appendix B, the response of well JMP-09 during the slug test recovery period did not follow a typical well response pattern.

Based on the information above, it is apparent that there is only a limited thickness of saturated sandstone in the Castlegate Sandstone in the vicinity of the monitoring wells in the North Water Canyon and Joes Mill Pond areas. This observation is important, as it has previously been determined that, while there is a reasonable potential to produce moderate quantities of groundwater from fractured Castlegate Sandstone, there is a much more limited potential to produce useful quantities of groundwater from the Blackhawk Formation. This condition is principally related to the fact that permeable strata in the Blackhawk Formation commonly exist as lenticular, discontinuous sandstone channel deposits. These Blackhawk Formation sandstone channel deposits are typically encased vertically and horizontally by low permeability rocks. Consequently, while individual sandstone channels may be permeable and contain water (often ancient), the potential for groundwater recharge to these sandstone channel deposits is low. Thus, while wells screened in Blackhawk Formation sandstones may initially yield modest quantities of water, the potential for long-term sustainability of the groundwater source is probably not good. It should be noted, however, that there may be a greater potential to produce groundwater from sandy strata in the uppermost Blackhawk Formation in the North Water Canyon and Joes Mill Pond areas if the sandstone strata directly underlying the Castlegate Sandstone is appreciably fractured.

5.0 Conclusions and Recommendations

Because the conditions in the wells do not satisfy all the requirements for valid slug testing, the results presented here are provided for general purposes only and should be evaluated in light of the limitations of the testing. Additionally, because of the locations of the well screened intervals, the characteristics indicated by the slug tests are generally <u>not</u> indicative of conditions in the Castlegate Sandstone.

The potential for the production of moderate quantities (a few gallons per minute) of groundwater from unfractured Castlegate Sandstone bedrock in the North Water Canyon and Joes Mill Pond areas is considered low. This is because of the limited saturated thickness of Castlegate Sandstone observed in the vicinity of the monitoring wells (from about 1 to 18 feet). If an attempt is made to produce groundwater from the Castlegate Sandston, the area of greatest potential seems to be near well NW2-09, which has the greatest saturated thickness of Castlegate Sandstone of any of the wells (~18 feet). Because of the likely unsatisfactory long-term performance of a well screened in unfractured Blackhawk Formation rocks, such a production well is not recommended.

Alternatively, if an area of known subsidence fracturing could be intercepted, there may be increased potential for groundwater production from the base of the Castlegate Sandstone or possibly from the uppermost Blackhawk Formation if the strata in the well location were to be appreciably fractured and the fracture network was well interconnected with adjacent areas. The locations of subsidence fractures has been mapped in the area previously by Canyon Fuel Company, LLC (Petersen Hydrologic, 2007b).

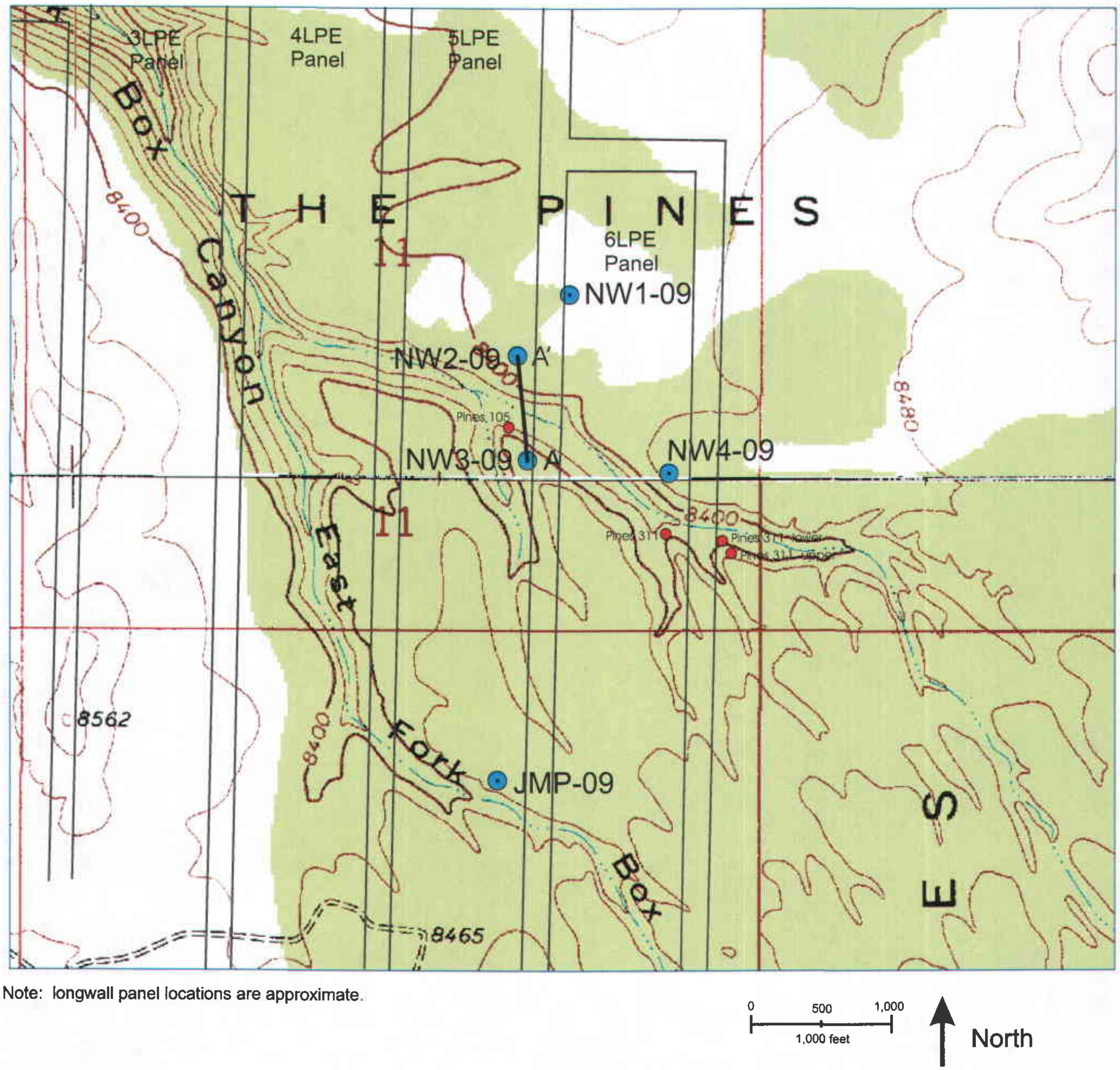
4.0 References Cited

Freeze, R.A., and Cherry, J.C., 1979, Groundwater, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 604 p.

Hvorslev, M.J., 1951, Time lag and soil permeability in ground water observations, U.S. Army Corps of Engineers Waterways Experimental Station, Bulletin 36, 50 p.

Petersen Hydrologic, LLC, 2007a, Investigation of subsidence-related impacts to groundwater systems in the North Water and Joes Mill Pond areas and proposed groundwater mitigation activities, Sufco Mine, unpublished consulting report for Canyon Fuel Company, LLC.

Petersen Hydrologic, LLC, 2007b, Report of 2007 Hydrogeologic field investigations; supplemental information for the report: investigation of subsidence- related impacts to groundwater systems in the North Water and Joes Mill Pond areas and proposed groundwater mitigation activities, Sufco Mine, unpublished consulting report for Canyon Fuel Company, LLC.



Note: longwall panel locations are approximate.

Figure 1 Locations of Castlegate Sandstone monitoring wells in the North Water Canyon area (see Figure X for cross-section A - A').

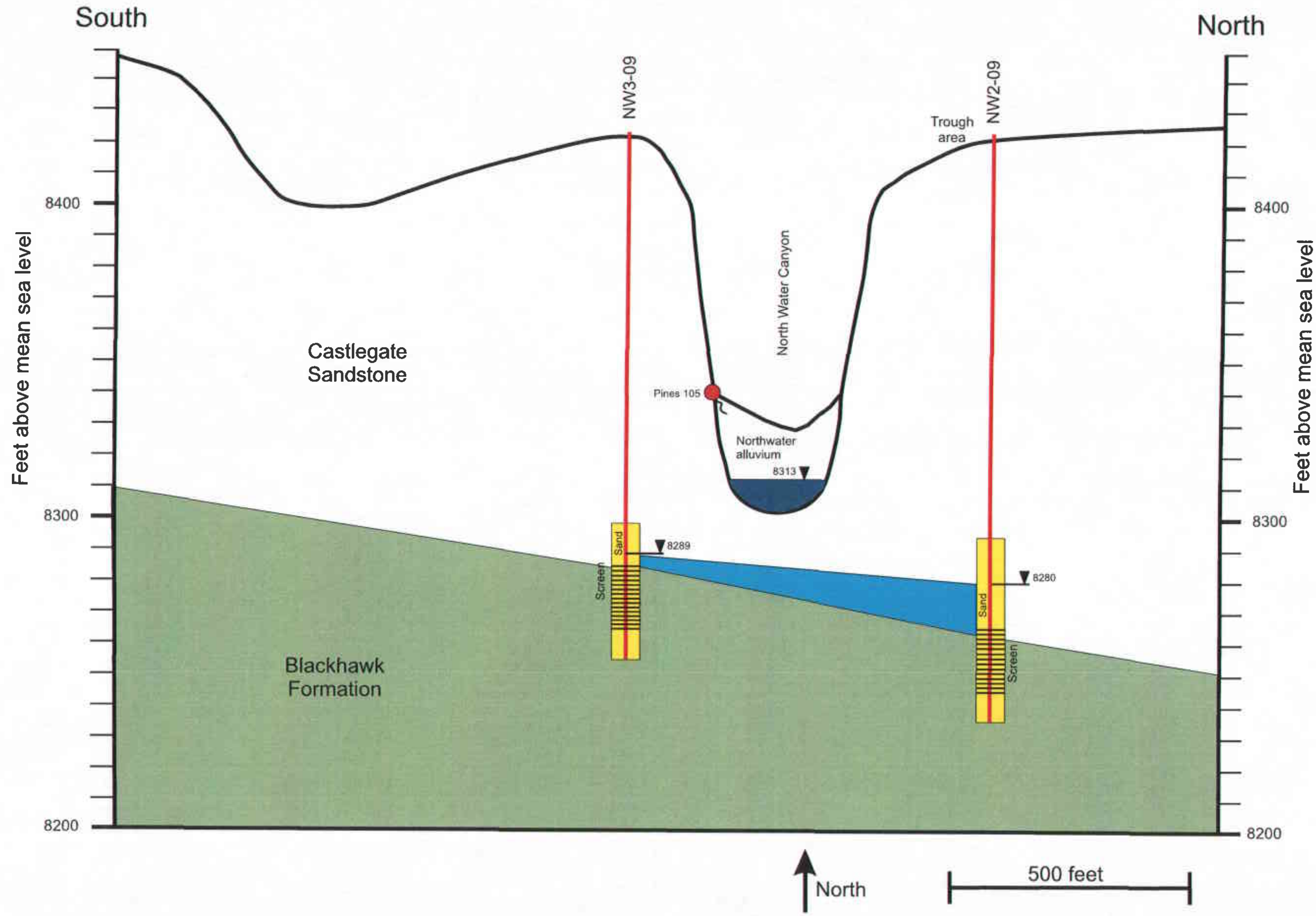


Figure 2 North-south cross-section through the North Water Canyon area (see Figure 2 for cross-section location).

NW2-09

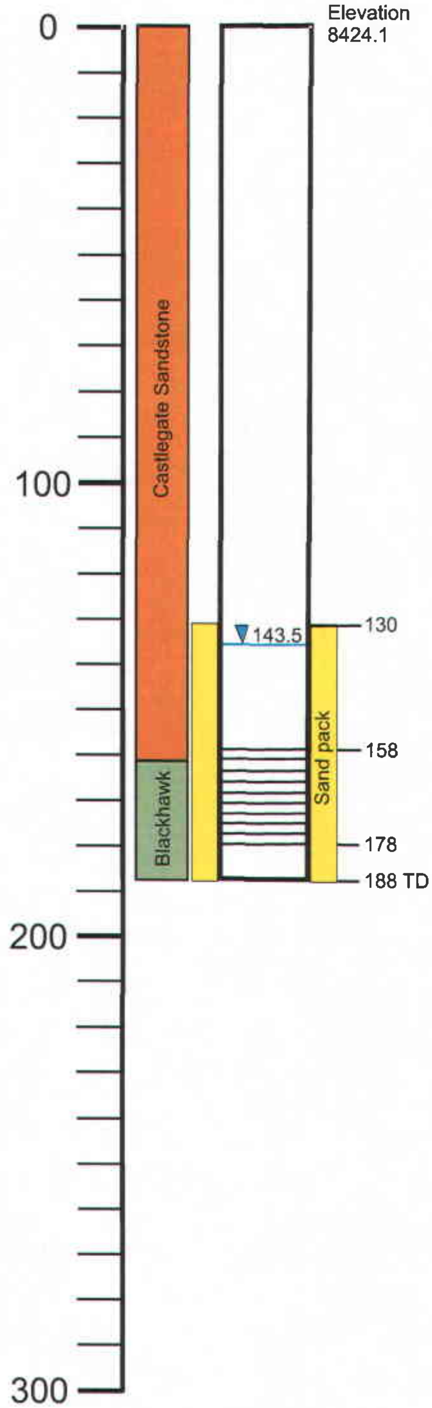


Figure 3b Construction details for NW2-09

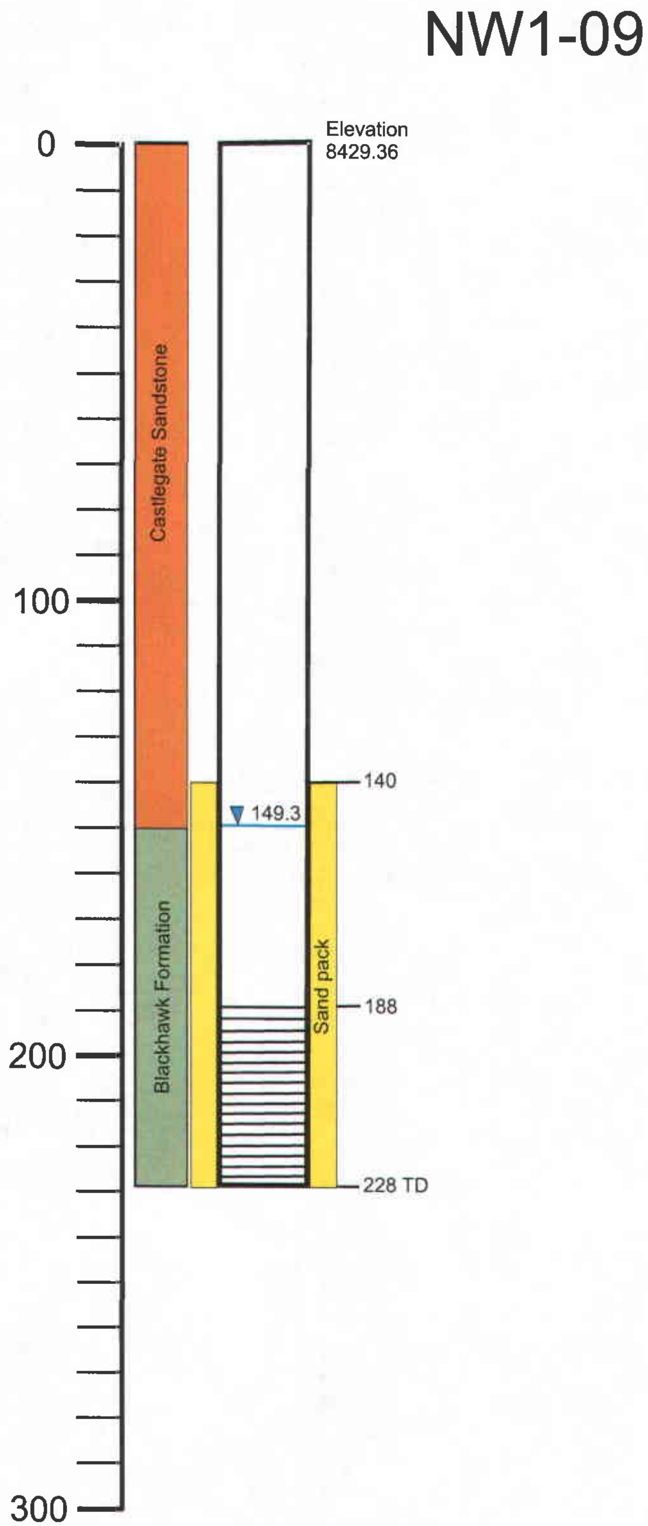


Figure 3a Construction details for NW1-09

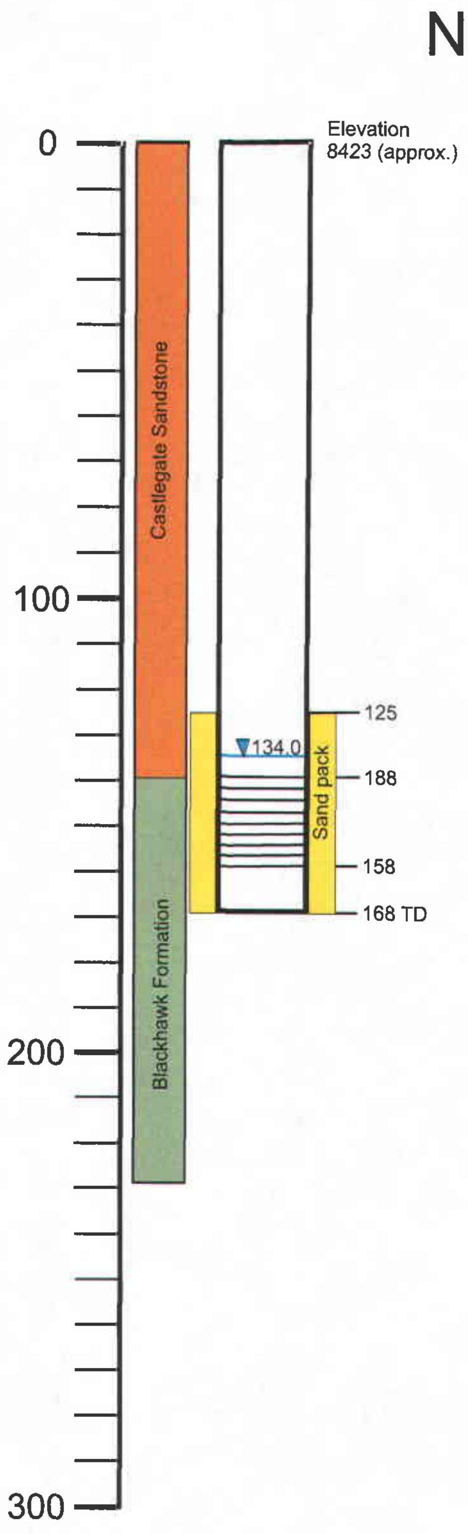


Figure 3c Construction details for NW3-09

NW4-09

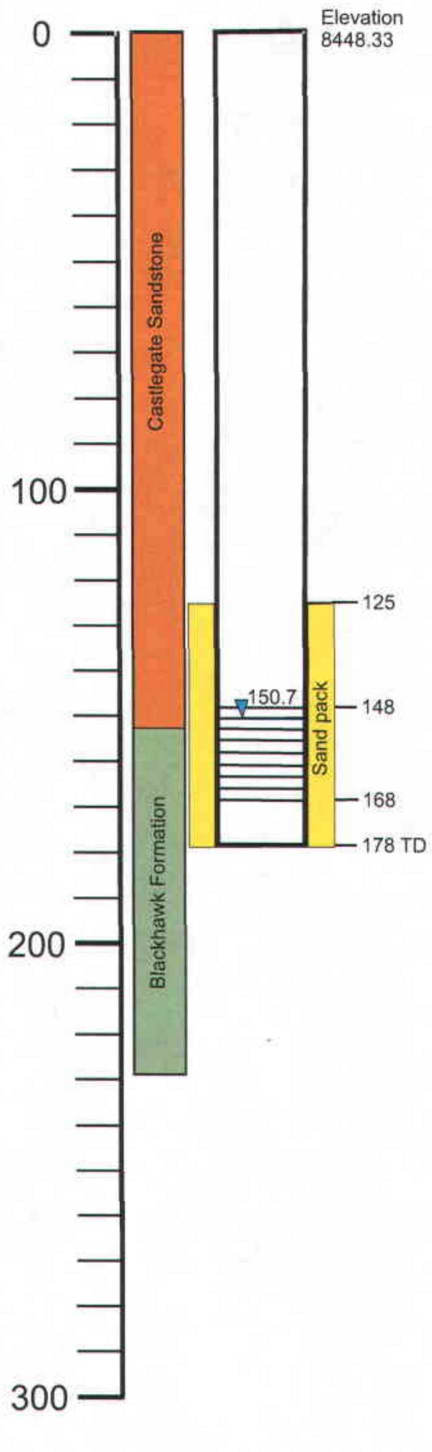


Figure 3d Construction details for NW4-09

JMP-09

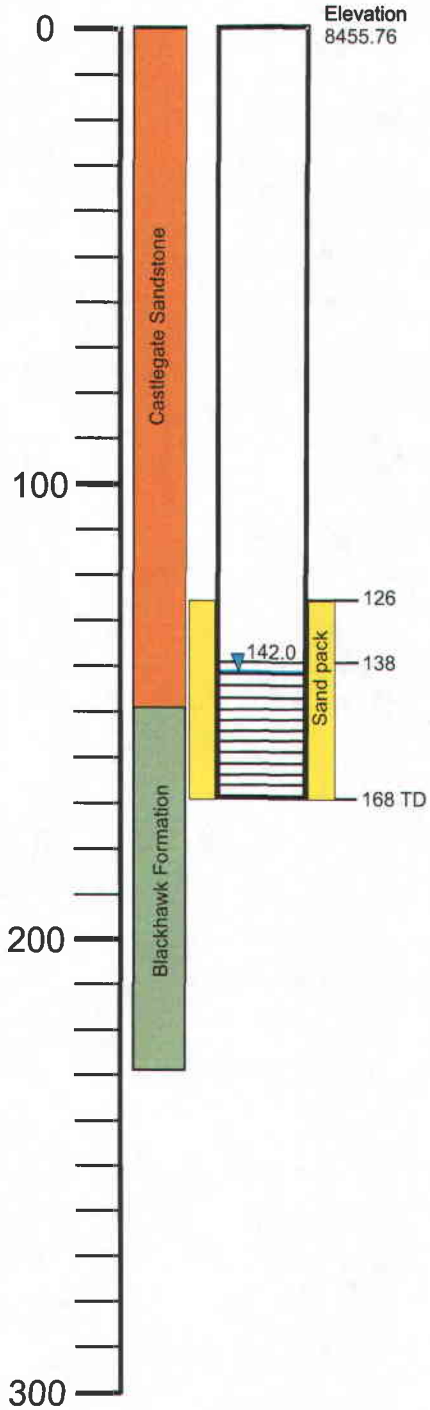


Figure 3e Construction details for JMP-09

Table 1 Completion information for Castlegate Sandstone monitoring wells.

	NW1-09	NW2-09	NW3-09	NW4-09	JMP-09
Well depth (feet below surface)	228	188	168	178	168
Well borehole diameter (feet)	0.333	0.333	0.333	0.333	0.333
Well casing ID (feet)	0.0833	0.0833	0.0833	0.0833	0.0833
Well screen from (feet below ground surface)	188	158	138	148	138
Well screen to (feet below ground surface)	228	178	158	168	168
Well screen length (feet)	40	20	20	20	30
Sand pack from (feet below ground surface)	140	130	125	130	126
Sand pack to (feet below ground surface)	228	188	168	178	168
Sand Pack length (feet)	88	58	43	48	42
Well screen slot size	0.010	0.010	0.010	0.010	0.010
Depth to Castlegate/Blackhawk contact (feet)	150.5	161.8	138.5	153	149
Static water level - 11/09 and 2/10 (feet below top of cas	149.27	143.54	134.02	150.73	142.01

Note: All wells drilled in July and August 2009

Table 2 Water level measurements from Castlegate Sandstone monitoring wells.

	28-Aug-09	11-Sep-09	6-Oct-09	2-Nov-09	4-Nov-09	6-Nov-09	12-Feb-10
NW1-09	148.86	148.21	148.49	148.57	149.27	---	---
NW2-09	143.94	143.07	143.44	143.55	143.45	143.38	---
NW3-09	133.78	---	---	---	---	---	134.02
NW4-09	151.60	150.35	---	150.49	150.41	152.13	---
JMP-09	144.89	149.1	145.11	139.21	138.78	142.01	---

Note: All measurements are in feet relative to top of PVC casing.

Table 3 Slug test results for Castlegate Sandstone monitoring wells.

	Hydraulic Conductivity* (well slotted screen length assumption)	Hydraulic Conductivity* (screen length equals sand pack length assumption)
NW1-09	1.56×10^{-5} cm/sec	8.13×10^{-6} cm/sec
NW2-09	1.41×10^{-4} cm/sec	5.94×10^{-5} cm/sec
NW3-09	Not tested	Not tested
NW4-09	2.11×10^{-4} cm/sec	1.04×10^{-4} cm/sec
JMP-09	2.04×10^{-4} cm/sec	1.55×10^{-4} cm/sec

*Note: One or more conditions required for a valid slug test were not present in each of the tested wells.

Appendix A

Geologic Logs

Appendix B

Slug Testing Information

Appendix A Hvorslev Method slug test calculations.

Hvorslev Equation for slug test:
K = r^2 ln (L/R) / 2LTo

K = hydraulic conductivity
r = radius of well casing
R = radius of well screen
L = length of well screen
T_o = time it takes for the water level to fall to 37% of the initial change

Assumptions: specified screen length, screen diameter = 4 inches

	r (feet)	R (feet)	L (feet)	T_o (seconds)
NW1-09	0.0417	0.167	40	232
NW2-09	0.0417	0.167	20	45
NW4-09	0.0417	0.167	20	30
JMP-09	0.0417	0.167	30	22.5

Hydraulic Conductivity values (feet/second)

NW1-09	5.13E-07	ft/sec
NW2-09	4.62E-06	ft/sec
NW4-09	6.93E-06	ft/sec
JMP-09	6.69E-06	ft/sec

Hydraulic Conductivity values (centimeters/second)

NW1-09	**1.56E-05**	**cm/sec**
NW2-09	**1.41E-04**	**cm/sec**
NW4-09	**2.11E-04**	**cm/sec**
JMP-09	**2.04E-04**	**cm/sec**

Appendix A Hvorslev Method slug test calculations.

Hvorslev Equation for slug test:
K = r^2 ln (L/R) / 2LTo

K = hydraulic conductivity
r = radius of well casing
R = radius of well screen
L = length of well screen
T_o = time it takes for the water level to fall to 37% of the initial change

Assumptions: Sand pack = screen length, 4-inch casing diameter

	r (feet)	R (feet)	L (feet)	T_o (seconds)
NW1-09	0.0417	0.167	88	232
NW2-09	0.0417	0.167	58	45
NW4-09	0.0417	0.167	48	30
JMP-09	0.0417	0.167	42	22.5

Hydraulic Conductivity values (feet/second)

NW1-09	2.67E-07	ft/sec
NW2-09	1.95E-06	ft/sec
NW4-09	3.42E-06	ft/sec
JMP-09	5.09E-06	ft/sec

Hydraulic Conductivity values (centimeters/second)

NW1-09	**8.13E-06**	**cm/sec**
NW2-09	**5.94E-05**	**cm/sec**
NW4-09	**1.04E-04**	**cm/sec**
JMP-09	**1.55E-04**	**cm/sec**

Appendix A Hvorslev Method slug test calculations.

Hvorslev Equation for slug test:
K = r^2 ln (L/R) / 2LTo

K = hydraulic conductivity
r = radius of well casing
R = radius of well screen
L = length of well screen
T_o = time it takes for the water level to fall to 37% of the initial change

Assumptions: Specified screen length, screen diameter = 1 inch

	r (feet)	R (feet)	L (feet)	T_o (seconds)
NW1-09	0.0417	0.167	88	232
NW2-09	0.0417	0.167	58	45
NW4-09	0.0417	0.167	48	30
JMP-09	0.0417	0.167	42	22.5

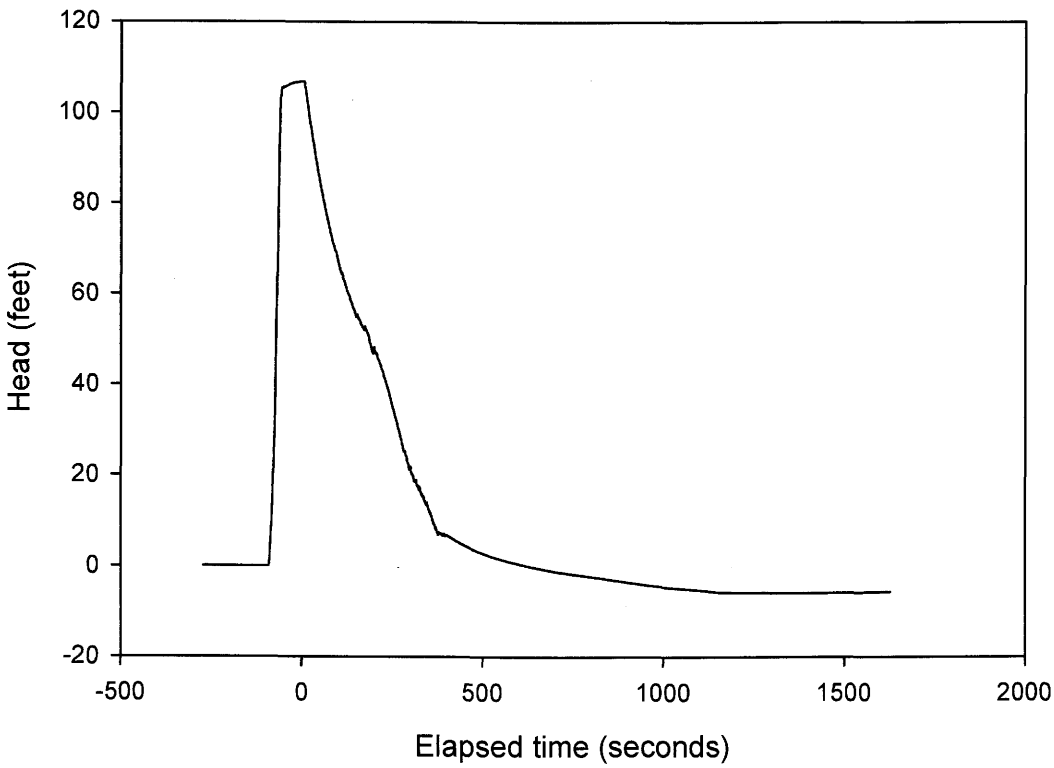
Hydraulic Conductivity values (feet/second)

NW1-09	2.67E-07	ft/sec
NW2-09	1.95E-06	ft/sec
NW4-09	3.42E-06	ft/sec
JMP-09	5.09E-06	ft/sec

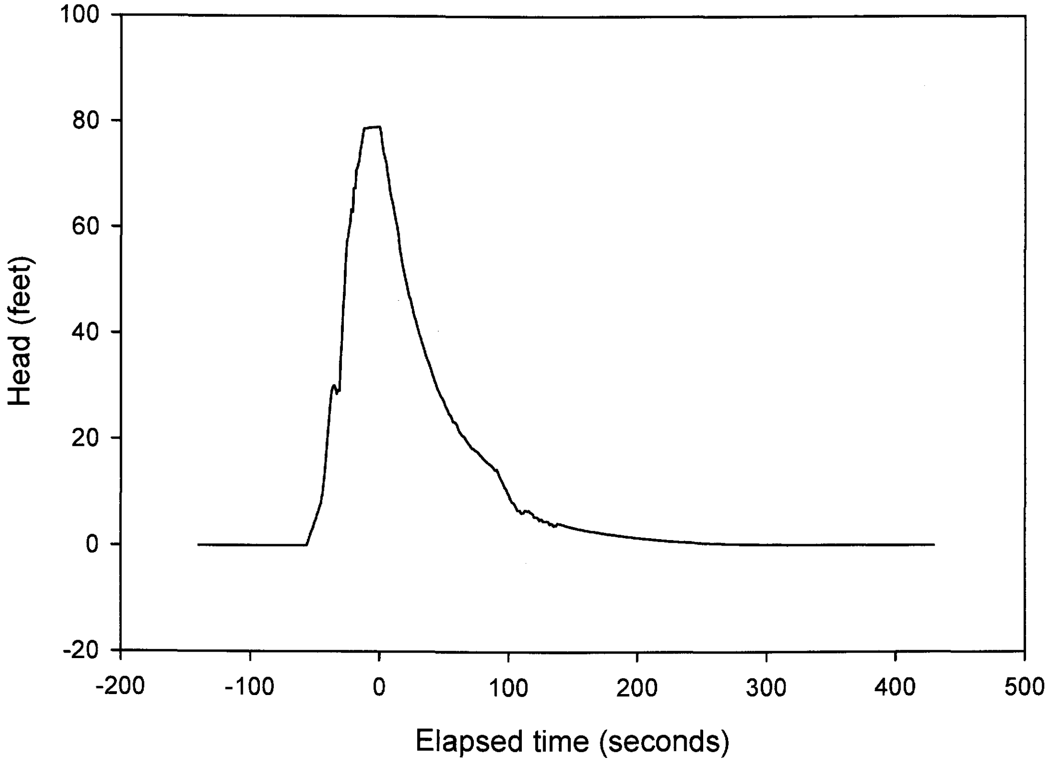
Hydraulic Conductivity values (centimeters/second)

NW1-09	**8.13E-06**	**cm/sec**
NW2-09	**5.94E-05**	**cm/sec**
NW4-09	**1.04E-04**	**cm/sec**
JMP-09	**1.55E-04**	**cm/sec**

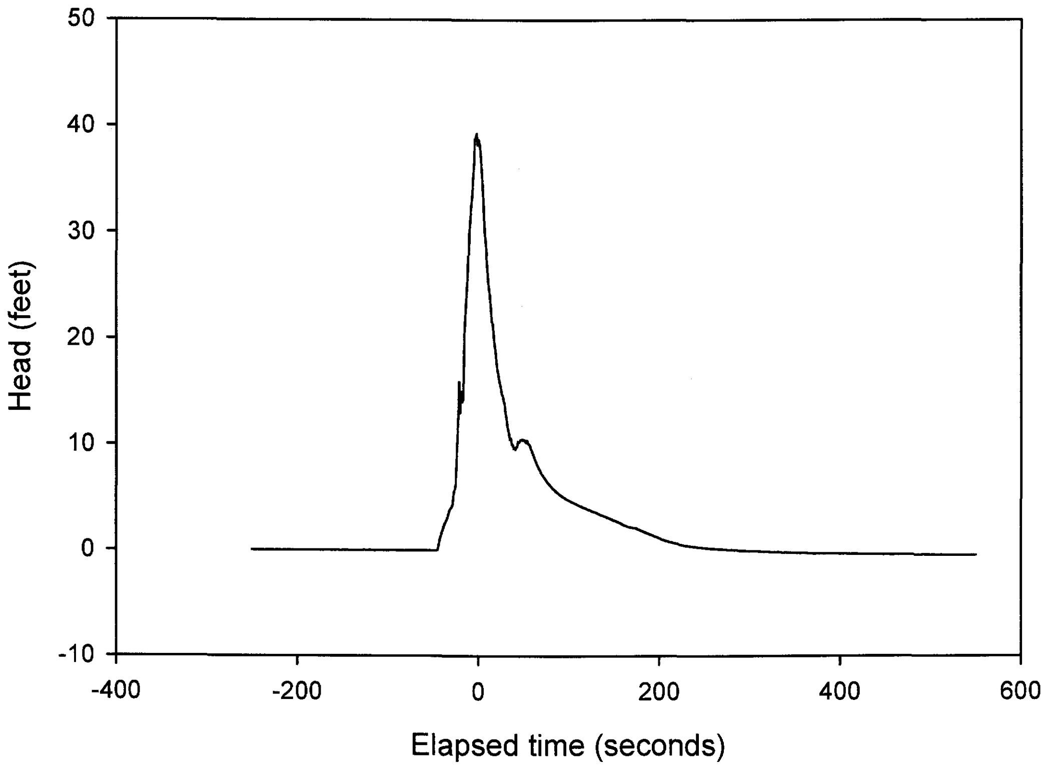
NW1-09 Slug Test



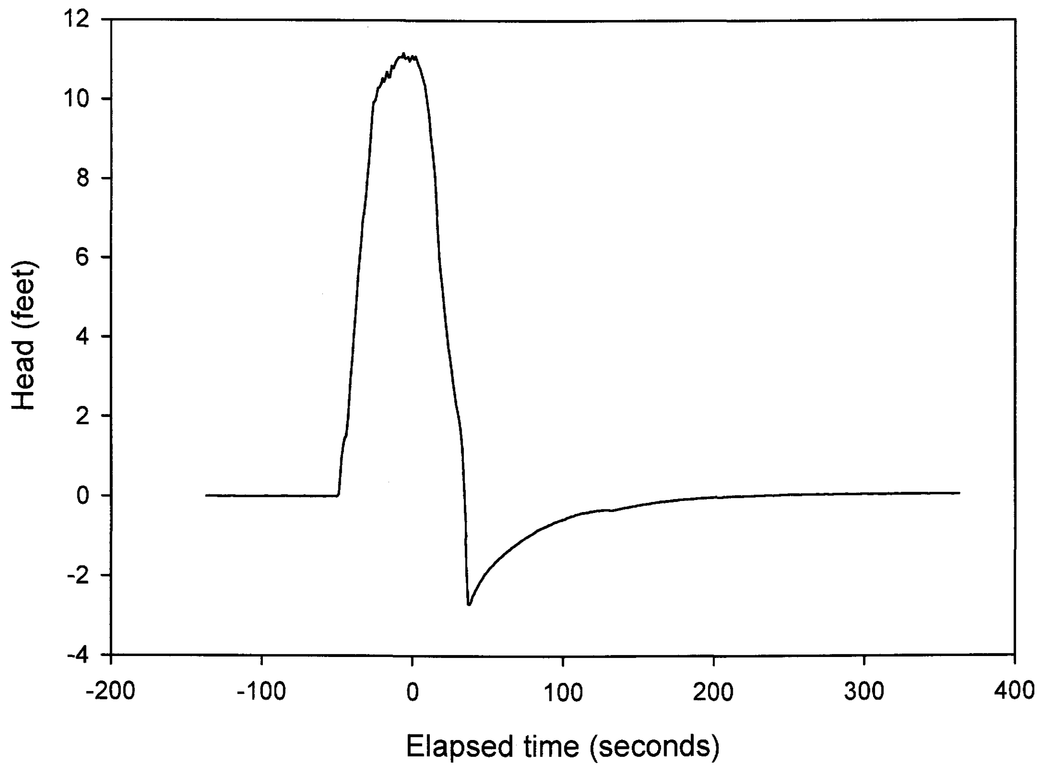
NW2-09 Slug Test



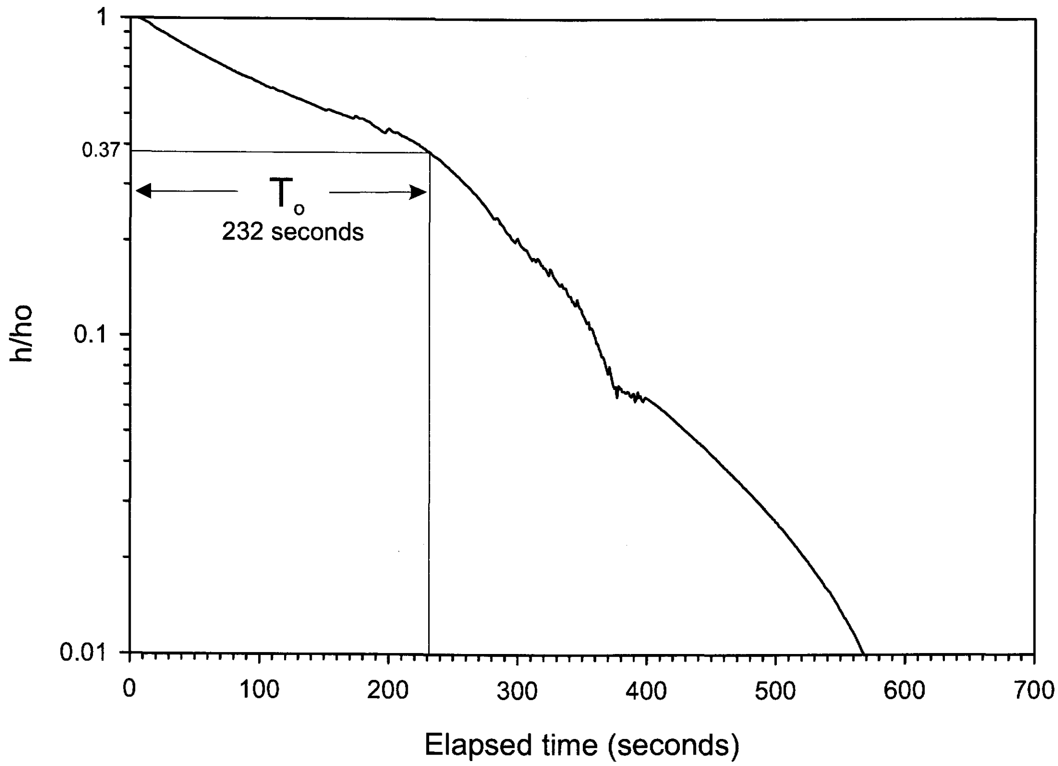
NW4-09 Slug Test



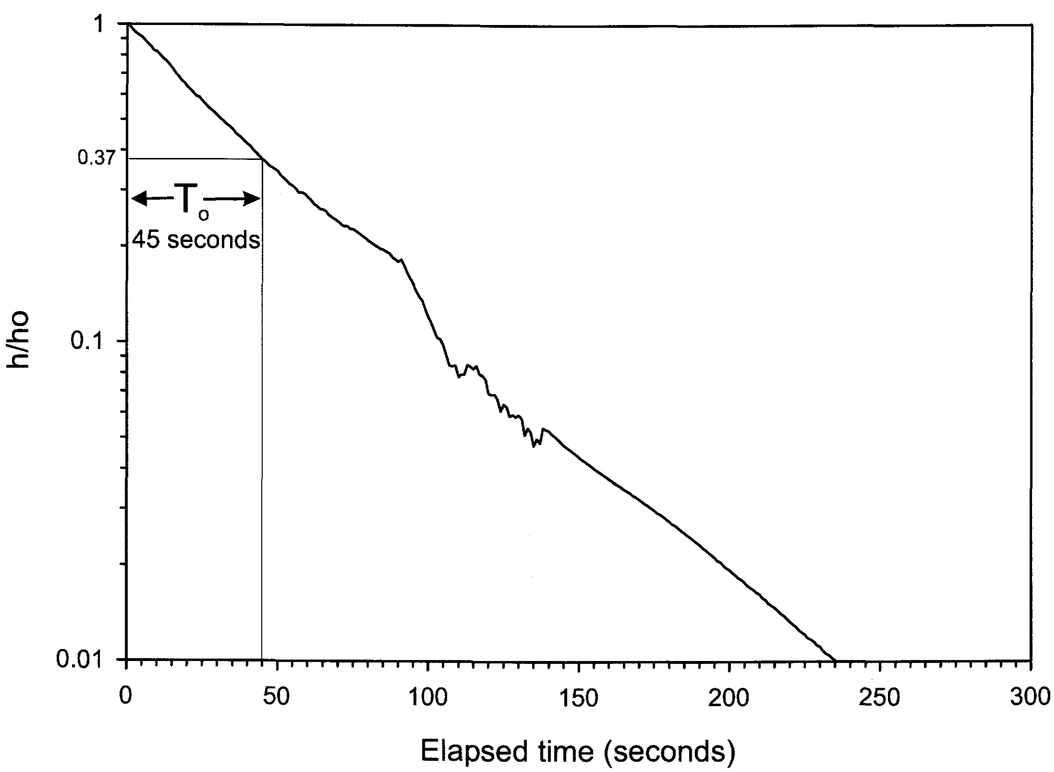
JMP-09 Slug Test



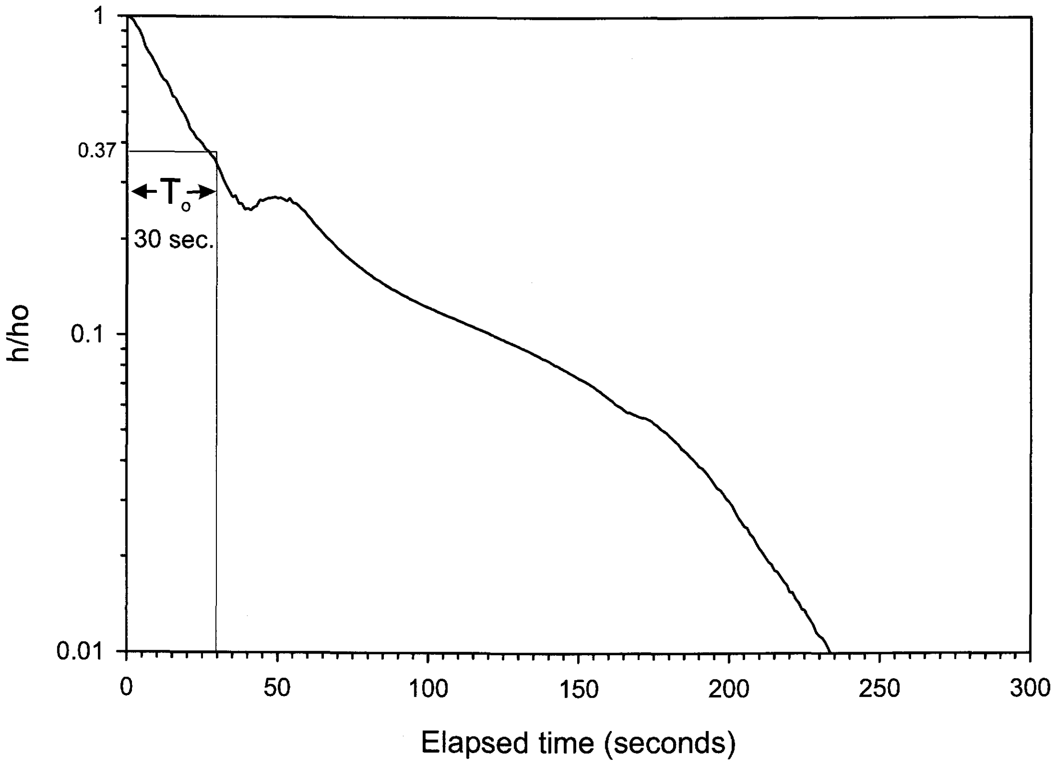
NW1-09 Hvorslev h/ho plot

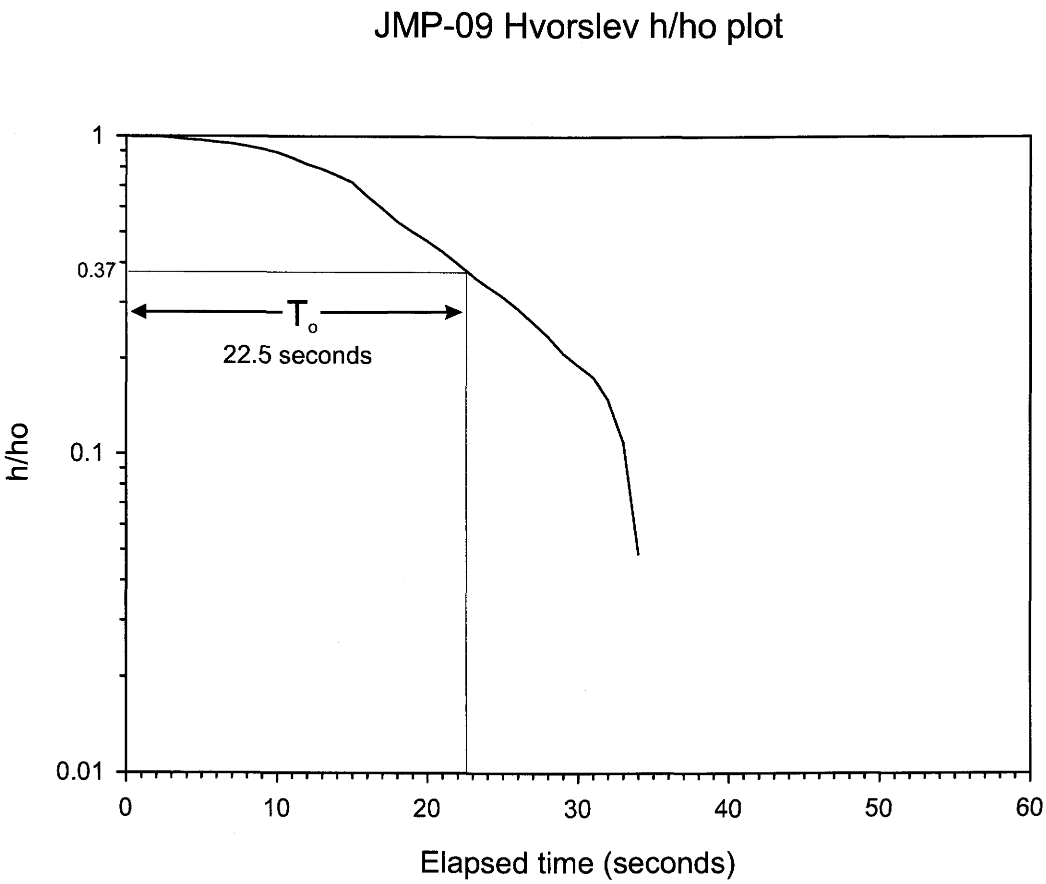


NW2-09 Hvorslev h/ho plot



NW4-09 Hvorslev h/ho plot




JMP-09 Hvorslev h/ho plot
1
0.37
0.1
0.01
h/ho
T_o
22.5 seconds
0
10
20
30
40
50
60
Elapsed time (seconds)